Saint-Laurent
Vision 2000

Intervention SLV 2000

Canada

Québec

SLV 2000 REPORT ON TOXIC EFFLUENT REDUCTION IN 38 PULP AND PAPER MILLS

1993-1996

June 1999

Published by authority of the Minister on the Environment
© Minister of Public Works and Government Services Canada 1999
Catalogue No, : En40-574/1999E
ISBN 0-662-27684-1

Internet site
www.slv2000.qc.ec.gc.ca

Document disponible en français sous le titre de :
Bilan de l'évaluation de la réduction des rejets liquides toxiques des 38 fabriques de pâtes et papiers de SLV 2000, 1993-1996

103-03636/

FOREWORD

This document has been produced under the Protection Component of the SLV 2000 program. It was prepared with contributions from many employees of the ministère de l'Environnement du Québec and Environment Canada (EC). It reviews the status of toxic effluents from Group III, the 38 pulp and paper mills under SLV 2000.

Important changes have recently taken place in the pulp and paper sector which have a direct impact on toxic effluents. The period covered by this report is from 1993 to 1996, (the program reference year to one year after secondary industrial wastewater treatment systems were introduced in most of the plants). Given the complexity of acquiring and processing information, the 1996 data were the most recent available to us at the time of writing.

To provide more detailed information about the pulp and paper mills participating in SLV 2000, fact sheets[1] have been written about each pulp and paper mill participating in SLV 2000. They are available by mail and on the Internet.

Finally, it is important to note that this summary does not deal with pulp and paper mill regulatory compliance. Readers interested in this issue should consult the ministère de l'Environnement du Québec and Environment Canada compliance reports.

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You can adress all questions concerning pulp and paper mills and law enforcement in Québec, to the regional branches of the ministère de l'Environnement du Québec.

ABSTRACT

The federal and provincial governments have been working together since 1988 to safeguard the St. Lawrence River. The St. Lawrence Action Plan, created in 1989, was renamed St. Lawrence Vision 2000 (SLV 2000) in 1994. The goal remained the same: to conserve and protect the St. Lawrence ecosystem so as to return use of the river to the public in a perspective of sustainable development. Thirty eight pulp and paper mills located all along the St. Lawrence River and some of its tributaries are among the 106 industrial plants targeted by SLV 2000. The Protection component of SLV 2000 is aimed at reducing toxic effluent discharges to the environment and in the long-term, virtually eliminating discharges into the environment of 11 toxic, persistent and bioaccumulative toxic substances. Another objective for the pulp and paper sector is the evaluation of toxic discharges in terms of environmental objectives and the establishment of corrective measures for the optimum reduction of any harmful impact on the receiving environment.

From 1993 to 1996, these 38 mills implemented cleanup measures and invested about $700 million in modifications to their industrial processes. The result was a 92% reduction in the discharge of toxic substances, a 51% reduction in suspended solids (SS) discharges and a 92% drop in biochemical oxygen demand (BOD_5). The toxic, persistent and bioaccumulative substances present in liquid discharges were reduced by 90%. In 1996, 86% of the pulp and paper effluents were non toxic according accute lethality results of the rainbow trout bioassay.

RÉSUMÉ

Depuis 1988, les gouvernements fédéral et provincial unissent leurs efforts afin d'assurer la sauvegarde du Saint-Laurent. En 1989, le Plan d'action Saint-Laurent (PASL) a été créé. Saint-Laurent Vision 2000 (SLV 2000) a été institué en 1994 dans le but d'assurer la continuité du PASL. SLV 2000 vise à conserver et protéger l'écosystème du Saint-Laurent, afin de redonner l'usage du fleuve aux citoyens et citoyennes dans une perspective de développement durable. Trente-huit (38) fabriques de pâtes et papiers situées le long du Saint-Laurent et de certaines rivières tributaires du Saint-Laurent font partie des 106 établissements industriels ciblés par le volet Protection de SLV 2000. Les objectifs du volet Protection de SLV 2000 sont la réduction des rejets liquides toxiques à l'environnement et l'élimination virtuelle à long terme des rejets de onze substances toxiques, persistantes et bioaccumulables ainsi que l'établissement des correctifs requis pour réduire de façon optimale les effets dommageables sur le milieu récepteur.

De 1993 à 1996, les 38 fabriques de pâtes et papiers ont mis en œuvre, dans le cadre du respect des réglementations fédérales et provinciales, des mesures d'assainissement et ont apporté des modifications aux procédés. Un investissement global d'environ 700 millions de dollars a été consenti pour les 38 fabriques de pâtes et papiers visés par SLV 2000. Ces changements ont permis de réduire les substances toxiques dans les rejets liquides de 92 % et de diminuer les charges des matières en suspension (MES) et de la demande biochimique en oxygène (DBO_5) de 51 % et 92 %, respectivement. La réduction des substances toxiques, persistantes et bioaccumulables visées par l'élimination virtuelle est de 90 %. En 1996, 86 % des effluents étaient non toxiques selon l'essai de détermination de la létalité aiguë chez les Truites arc-en-ciel.

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1. INTRODUCTION

On June 3, 1988, the governments of Canada and Quebec signed a co-operative agreement to harmonize efforts to protect the St. Lawrence River. The five-year St. Lawrence Action Plan (SLAP) was signed in June 1989. The objective of the Protection Component of SLAP was to reduce toxic liquid discharges from 50 industrial plants along the St. Lawrence and Saguenay rivers by 90%. St. Lawrence Vision 2000 (SLV 2000), signed in April 1994, is a continuation of SLAP. SLV 2000 is aimed at conserving and protecting the St. Lawrence ecosystem in order to return use of the river to citizens, at the same time promoting sustainable development. The program includes an additional 56 industrial plants. This second phase focuses on reducing toxic liquid effluents and, in the long term, virtually eliminating 11 persistent bioaccumulative toxic substances.

Thirty-eight of the 106 industrial plants under SLV 2000 are pulp and paper plants. This report outlines toxic effluent reductions in the 38 plants from 1993 to 1996.

The document presents a brief overview of the pulp and paper sector in Quebec, with emphasis on objectives and strategy adopted for the 38 pulp and paper plants registered in the SLV 2000 program. The information sources used to monitor effluent quality are also described. Problems involved in evaluating toxic substances in effluents are discussed, along with the Chimiotox Index, which is the means used to measure loads of toxic substances. The main achievements and cleanup measures are listed, as are the effluent reduction results obtained from 1993 to 1996 as determined by the Chimiotox Index. Finally, the report includes results with respect to the virtual elimination of persistent bioaccumulative toxic substances, toxicity of effluents in 1996 and a summary of environmental impact monitoring studies.

2. BACKGROUND

2.1 The pulp and paper sector in Quebec

Sixty-five pulp and paper mills were operating in Quebec in 1996, close to 40% of the paper mills in Canada. The pulp and paper sector is governed by the provincial *Pulp and Paper Mills Regulations* and the federal *Pulp and Paper Effluent Regulations*, both of which were revised and amended in 1992.

The first pulp and paper mill effluent regulations came into force in 1971 under the *Fisheries Act*. These regulations were intended to protect fish and fish habitats by controlling suspended solids (SS), biochemical oxygen demand (BOD_5) and effluents acutely lethal to fish. However, only some mills were subject to the regulations.

A second set of regulations was adopted in September 1979 by the Quebec government under the province's *Environment Quality Act*. These regulations set environmental standards for SS and BOD_5 effluent discharges, atmospheric emissions and waste management for all pulp and paper mills operating in Quebec. The effluent standards cover each stage of fiber processing. With respect to BOD_5 standards, the regulations made a distinction between plants in operation at the time they were adopted and those built after September 1979.

On May 20, 1992, the federal regulations were amended to apply to all Canadian plants as well as to outside processing facilities receiving pulp and paper mill effluents. The amendment also applied more stringent standards to most plants as of December 31, 1995 for suspended solids (SS), biochemical oxygen demand (BOD_5) and substances lethal to fish (LC_{50}). The new regulations also required that every pulp and paper mill conduct an Environmental Effects Monitoring (EEM) study every three years.

The provincial regulations were amended in 1992 as well. They contain more stringent standards than the original regulations. The standards are based on the total production of mills, which makes them easier to enforce. The new regulations contain standards for pH, temperature, BOD_5, SS, absorbable halogenated organic compounds (AHOCs), hydrocarbons, polychlorinated biphenyls (PCBs), chlorinated dioxins and furans, and acutely lethal toxicity. Plants must also measure fatty and resin acids, chlorophenols, chemical oxygen demand (COD), aluminum, copper, nickel, lead and zinc. In addition, the regulations contain atmospheric emission and waste management standards for pulp and paper plants.

Finally, Quebec pulp and paper mills must also comply with the federal *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations,* the *Pulp and Paper Mill Defoamer and Wood Chip Regulations,* and the *Chlorobiphenyl Regulations.*

The pulp and paper industry is one of the driving forces of the economy, directly employing 27,000 persons. In 1995, the total value of pulp and paper exports from Quebec was $7.1 billion. In 1996, Quebec exported 79% of its pulp and paper production, which represented 15% of all Quebec exports. That same year, the Quebec pulp and paper industry produced a total of 9.3 million tonnes.

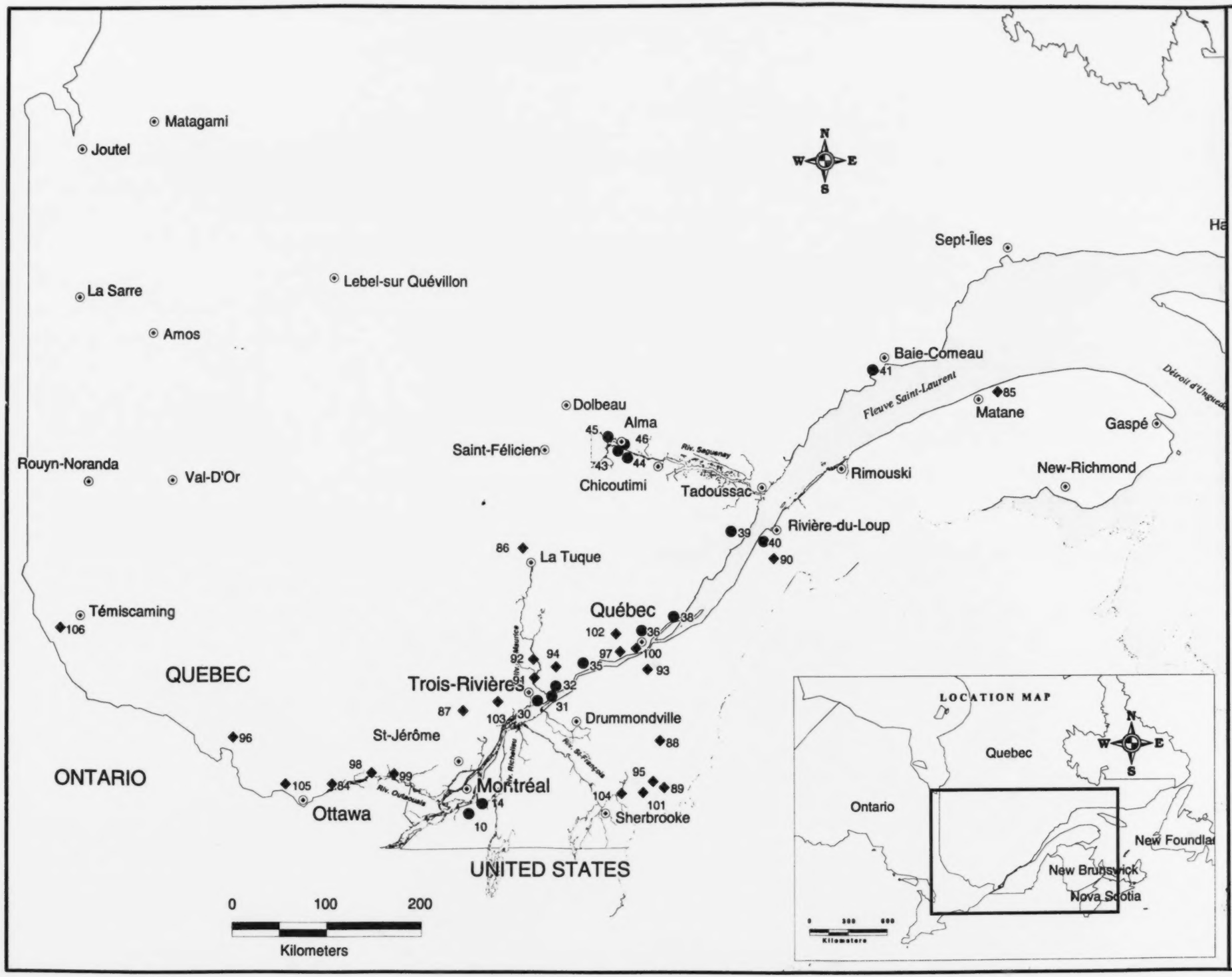
In order to comply with federal and provincial regulations, the pulp and paper industry had invested $1.2 billion in Quebec by the end of 1996. This capital went mainly to build biological effluent treatment systems, conduct programs to reduce freshwater intake and clean up atmospheric emissions from sulfate (Kraft) processes.

2.2 The 38 pulp and paper mills under SLV 2000

Thirty-eight pulp and paper mills in Quebec are registered in the SLV 2000 program. Figure 1 shows their locations along the St. Lawrence River and its tributaries and distinguishes between those registered in the St. Lawrence Action Plan and those covered by SLV 2000. The overall objective of the program is to reduce toxic effluents and virtually eliminate discharges of persistent bioaccumulative toxic substances in the long term. More specific objectives for pulp and paper plants include evaluating toxic discharges and taking corrective measures to optimize reduction of damage to the receiving environment.

The approach used to verify whether objectives have been met provides a complete picture of the situation. Two aspects are considered:

- the analytical aspect for measuring reduction of toxic substances and virtual elimination of persistent bioaccumulative toxic substances;
- the toxicological aspect for verifying effluent toxicity.



Name of the Pulp and Paper mills

SLAP

- ●10- Spexel inc. (Beauharnois)
- ●14- Les Papiers Perkins ltée (Candiac)
- ●30- Tripap inc. (Trois-Rivières)
- ●31- Abitibi-Consolidated inc., division Wayagamack (Trois-Rivières)
- ●32- Kruger inc., division du papier journal et papier couché (Trois-Rivières)
- ●35- Produits Forestiers Alliance inc. (Donnacona)
- ●36- Les Produits Forestiers Daishowa ltée (Québec)
- ●38- Abitibi consolidated inc., (Beaupré)
- ●39- Produits Forestiers Donohue inc. (Clermont)
- ●40- F.F. Soucy inc. (Rivière-du-Loup)
- ●41- Produits forestiers Donohue inc. (Baie-Comeau)
- ●43- FjordCell inc. (Jonquière)
- ●44- Abitibi-Consolidated inc., division Port Alfred (La Baie)
- ●45- Abitibi consolidated inc., (Alma)
- ●46- Abitibi-consolidated inc. (Jonquière)

SLV2000

- ◆100- J. Ford ltée (Portneuf)
- ◆101- Kruger inc., division du papier journal et papier couché (Bromptonville)
- ◆102- Mallette Québec inc. (Saint-Léonard de Portneuf)
- ◆103- Matériaux Cascades inc. (Louiseville)
- ◆104- Papiers Scott ltée (Lennoxville)
- ◆105- Les produits Forestiers E.B. EDDY ltée (Hull)
- ◆106- Tembec inc. (Témiscamingue)
- ◆84- Bowater pâtes et papiers Canada inc. (Gatineau)
- ◆85- Cartons Saint-Laurent inc. (Matane)
- ◆86- Cartons Saint-Laurent inc. (La Tuque)
- ◆87- Cascades inc., division Joliette (Joliette)
- ◆88- Les Industries Cascades inc. (Kingsey Falls)
- ◆89- Cascades East Angus inc. (East Angus)
- ◆90- Pâte Mohawk ltée (Saint-Antonin)
- ◆91- Abitibi-Consolidated inc., division Belgo (Shawinigan)
- ◆92- Abitibi-Consolidated inc., division Laurentides (Grand-Mère)
- ◆93- Désencrage Cascades, division Rolland inc. (Breakeyville)
- ◆94- Désencrage C.M.D. inc. (Cap-de-la-Madeleine)
- ◆95- Papiers Domtar inc., Centre d'affaires Windsor (Windsor)
- ◆96- Emballages Stone (Canada) inc., division Pontiac (Portage-du-Fort)
- ◆97- BPCO (Division EMCO ltée) (Pont-Rouge)
- ◆98- Papiers Masson ltée (Masson)
- ◆99- Industries James MacLaren inc., division Pâte Kraft (Thurso)

Figure 1. Location of the 38 Pulp and Paper mills

March, 1999

The Protection Component of SLV 2000 has been organized around the following four activities:

1. Inventory:

   To specifically target the problems of each plant, a complete inventory was taken and regularly updated for the 38 pulp and paper mills. At the same time, a fact sheet summarizing the information gathered was produced for each industrial plant.

2. Effluent characterization:

   Based on the characterization results of the ministère de l'Environnement du Québec Industrial Waste Reduction Program (IWRP) and the results of SLAP characterization campaigns, a report on priority toxic substances in the 38 pulp and paper plants was drawn up. The report provided an overview of progress with respect to toxic inputs to effluents from 1993 to 1996.

3. Acquisition of effluent analysis data:

   To complete the survey of priority toxic substances from the 38 pulp and paper mills, data from analysis reports supplied monthly by the plants in accordance with regulatory requirements were obtained and compiled.

4. Communications:

   The information and results obtained are collated and presented in various formats for a given period.

Many players were involved in carrying out activities under the Protection Component of SLV 2000. The technical and professional personnel of 13 ministère de l'Environnement du Québec administrative regions (11 in the case of the pulp and paper mills) shared responsibility for direct intervention with priority plants. The staff of Environment Canada's Intervention SLV 2000 section were responsible for compiling data and the inventory as well as for producing fact sheets and reports.

3. EFFLUENT QUALITY MONITORING

In the case of the 38 pulp and paper mills associated with SLV 2000, changes in effluent quality from 1993 to 1996 were monitored using three sources of information: the inventory, toxic substances characterization data (SLAP and Industrial Waste Reduction Program (IWRP)) and monthly effluent

quality data provided by the pulp and paper mills in accordance with regulatory requirements (physicochemical and toxicological data).

3.1 Inventory

The computerized inventory contains general information about each plant, a description of its manufacturing processes, data on water use and effluents, a description of cleanup measures and recent changes in processes and cleanup systems, and information concerning regulatory requirements on effluents and technological development projects that have been completed or are under way.

Data gathered to prepare the inventory and throughout the activities of the Protection Component have been used to write fact sheets[ref(1)] on each industrial plant covered by SLV 2000. Each fact sheet covers:

- descriptions of the facilities
- principal raw materials and finished products
- loads of principal monitoring parameters characterizing effluents at the beginning of the program
- resources and uses to preserve
- environmental discharge objectives
- description of the wastewater treatment system
- prevention and cleanup measures implemented
- regulatory compliance
- abatement of toxic pollution as measured by the Chimiotox index
- virtual elimination of persistent toxic substances
- Potential Ecotoxic Effects Probe (PEEP) results
- loads of principal monitored parameters characterizing effluents at the end of 1995.

3.2 SLAP and IWRP characterizations

For the 15 pulp and paper mills that were covered by the SLAP, data from characterizations carried out under that program were used to establish the effluent discharge situation at the outset of the program in 1993. In the case of the other 23 pulp and paper mills, physicochemical data for 1993 were drawn from characterizations carried out under the IWRP.

3.3 Monthly effluent characterization reports (regulations)

The physicochemical and toxicological data for 1996 used in this report have been compiled from the monthly reports on effluent quality that the pulp and paper mills supply to the Ministère de l'Environnement du Québec each month, as stipulated in the regulations. Self-monitoring data includes: SS, BOD_5, PCBs, chlorinated dioxins and furans, hydrocarbons, fatty and resin acids, aluminum, copper, nickel, lead, zinc, chlorophenols and acute lethality to trout.

4. ANALYTICAL EVALUATION

4.1 Reduction of toxic substances: Chimiotox Index

4.1.1 Approach

One of the main objectives of the SLV 2000 Protection Component being to reduce toxic effluents discharged to the St. Lawrence by 106 priority industrial plants, a practical way had to be found to integrate, compile and analyse effluent characterization data. The Chimiotox Index, which was developed for the SLAP, was the appropriate tool, integrating toxic substance analysis results while taking into account the relative importance of each substance to provide a total measurement of the impact of toxic discharges.

4.1.2 The Chimiotox Index

The Chimiotox Index is a mathematical tool that provides an overview of toxic substances discharged into the environment. Indicators are calculated based on toxic substance characterization. Each result is first expressed in the form of a daily load (kg/d), then weighted using a toxicity factor assigned to each contaminant to obtain the Chimiotox unit. When the units for each contaminant are totaled, a Chimiotox indicator is obtained for each pulp and paper mill. The sum of the individual Chimiotox indicators provides an overall indicator for all of the 38 pulp and paper plants. Changes in the overall Chimiotox indicator reflect the rate of reduction of toxic substances.

This tool, developed under the SLAP, has been validated by scientific experts from universities and government. The document entitled *Évaluation externe du modèle CHIMIOTOX*[ref(2)] describes these expert validations. A brief description of the Chimiotox model appears in the appendix. The document entitled *The Chimiotox Index: A Toxic Waste Indicator*[ref(4)] provides a more detailed description of the main principles underlying the Chimiotox Index.

4.1.3 Reduction of toxic substances: Chimiotox Index for all 38 pulp and paper mills

Cleanup measures and changes in processes undertaken by the 38 pulp and paper plants covered by SLV 2000 between 1993 and 1996 resulted in a noteworthy reduction in contaminant discharges of contaminants. These reductions, expressed in terms of the Chimiotox Index, appear in Table 1. Between 1993 and 1996, the 38 pulp and paper mills reduced their total toxic effluent discharges by 92%.

Table 1 also summarizes the main cleanup measures carried out by the mills between 1993 and 1996. Of particular note is the introduction of secondary treatment, along with changes in processes, reduction at source and wastewater separation measures. Between 1993 and 1996, 25 of the 38 plants installed secondary treatment facilities, while three of the five mills that already had secondary treatment modified their systems. The effluents from four mills (plants 14, 87, 89 and 103) now go to municipal wastewater treatment plants. One mill (plant 85) now recirculates all of its industrial wastewater and no longer produces any contaminated effluent.

TABLE 1

Reduction in the Chimiotox Index between 1993 and 1996 and list of highlights for the 38 pulp and paper plants under SLV 2000

Number and name of industrial plant		1993 Chimiotox Index (C.U.[a])	Highlights	1996 Chimiotox Index (C.U.)	Reduction (%)
10	Spexel Inc. (Beauharnois)	1,279	Wastewater treatment program signed in 1989 Completion of several cleanup projects (1988-1994): reduction at source; process modifications; biological treatment of cooking liquor. Introduction of a sequential bioreactor secondary treatment system in 1995.	492	62
14	Les Papiers Perkins Ltée (Candiac)	182	Optimization of water recirculation and fiber recovery facilities since autumn 1993. Hook-up to municipal wastewater treatment plant in 1991. The increase in the Chimiotox Index is chiefly due to an increase in dioxins and furans.	7,541	-380
30	Tripap Inc. (Trois-Rivières)	*Not available*	Wastewater treatment program signed in 1988 (PFCP plant). Closure of PFCP plant in June 1992; reopened by Tripap in February 1994. Chemical pulp production ended in 1994. Introduction of primary flotation treatment and activated sludge secondary treatment systems in 1995.	1,159	*Not applicable*
31	Abitibi Consolidated Inc., division Wayagamak (Trois-Rivières).	86,311	Introduction of a white water recovery program in 1988. Process modifications in 1993 and separation of cooling water in 1995. Introduction of a sequential bioreactor secondary treatment system in 1995.	12,170	86
32	Kruger Inc., Division du papier journal et du papier couché (Trois-Rivières)	153,703	Start-up of a freshwater reduction program in 1993-1994. Introduction of an activated sludge secondary treatment system in 1995.	1,469	99
35	Produits forestiers Alliance Inc. (Donnacona)	23,799	Measures to reuse cooling water introduced in 1994. Introduction of an activated sludge secondary treatment system in 1995.	194	99
36	Les Produits Forestiers Daishowa Ltée. (Québec)	360,394	Wastewater treatment program signed in 1988. Process modifications in 1989 to reduce SS and BOD_5 loads. Closure of bisulfite and lignosulfite pulp plant in 1991. De-inking plant opened in 1992. Water recirculation and separation measures and activated sludge secondary treatment system introduced in 1995.	6,922	98
38	Abitibi Consolidated Inc. (Beaupré)	14,344	Introduction of primary treatment in 1989. Process modifications to cut SS and water intake (1989-1994). Introduction of an activated sludge secondary treatment system in 1995. Hook-up of domestic sewage to municipal sewer system in 1995.	3,291	77
39	Produits Forestiers Donohue Inc. (Clermont)	48,081	Reduction of freshwater intake, recycling of white water and separation of wastewater in 1990. Log barking halted in 1993. Introduction of an activated sludge secondary treatment system and a fluidized-bed biomass boiler in 1995.	212	99.5
40	F.F.Soucy Inc. (Rivière-du-Loup)	13,638	Water intake reduction and recirculation program launched between 1991 and 1994. Introduction of an activated sludge secondary treatment system and a biological sludge energy recovery system in 1995.	119	99
41	Produits Forestiers Donohue Inc. (Baie-Comeau) (anciennement Donohue QUNO Inc.)	51,725	Redirection of all final effluent to a submerged outfall in 1994. Introduction of an activated sludge secondary treatment system in 1995.	498	99
43	FjordCell Inc. (Jonquière)	24,358	Various cleanup measures launched between 1989 and 1993 to reduce wastewater volume and pollutant load. Cleanup projects (1989-1993). Closure of kraft pulp and chlorine bleaching plant in 1991. Introduction of an activated sludge secondary treatment system in 1995.	882	96

	Number and name of industrial plant	1993 Chimiotox Index (C.U.)	Highlights	1996 Chimiotox Index (C.U.)	Reduction (%)
44	Abitibi Consolidated Inc., Division Port-Alfred) (La Baie)	119,980	Cleanup measures taken in 1993 and 1994 to reduce concentrations of pollutants at source. Start-up of a sequential bioreactor secondary treatment system in 1995.	1,150	99
45	Abitibi Consolidated Inc. (Alma)	70,914	Replacement of bisulfite pulp with purchased kraft pulp in 1988 and 1989. Construction of a de-inking plant in 1995. Start-up of an activated sludge secondary treatment system in 1995. Wood floatage ended in 1996. Demolition of bisulfite pulp, grinder and wood conditioning mills in 1997-1998.	647	99
46	Abitibi Consolidated Inc. (Kénogami)	21,732	Replacement of wet barking system in 1993. Introduction of an activated sludge secondary treatment system in 1995. Separation of uncontaminated wastewater since 1995. Treatment of domestic sewage at the Jonquière wastewater treatment plant since autumn 1995.	1,298	94
84	Bowater pâtes et Papiers Canada Inc. (Gatineau)	110,986	Closure of plants and process modifications in 1993 and 1994, resulting in reduction of SS, BOD_5 and effluent discharge. Modification of primary treatment system in 1994. Introduction of an activated sludge secondary treatment system in 1995.	623	99
85	Cartons Saint-Laurent Inc. (Matane)	5,033	Closure of semi-chemical pulp mill in December 1993. Separation of cooling water, complete recirculation of industrial wastewater , and construction of a wood chip cooking liquor evaporation shop in 1995. Wood chip cooking shop restarted in 1996.	7	99.9
86	Cartons Saint-Laurent Inc. (La Tuque)	26,351	Changes in water management in 1994 and separation of non-contaminated water in 1995 to reduce effluent. Cleanup measures taken since 1993 to reduce pollutant loads. Introduction of an activated sludge secondary treatment system in 1995.	8,982	97
87	Cascades Inc. Division Joliette (Joliette)	222	Plant modernization launched in 1994 including significant water recirculation, fiber recovery and energy conservation efforts.	43	81
88	Les Industries Cascades Inc., (Kinsey Falls)	11,749	Modifications in 1994 and 1995 to reuse filtered white water in the plants. Introduction of an activated sludge secondary treatment system in 1995 and modification of primary treatment in 1995.	54	99.5
89	Cascades East Angus Inc. (East Angus)	4,535	Process modifications to decrease wastewater volume going to municipal sewage plant in 1995. Contribution to construction of the East Angus wastewater treatment plant.	4,889	-8
90	Pâte Mohawk Ltée. (St-Antonin)	1,341	Introduction of water recirculation and wastewater treatment measures in 1995.	150	89
91	Abitibi-Consolidated Inc., Division Belgo (Shawinigan)	19,934	Introduction of a sequential biological reactor secondary treatment system in 1995..	3,481	83
92	Abitibi-Consolidated Inc., Division Laurentides (Grand-Mère)	17,412	Introduction of a sequential biological reactor secondary treatment system in 1995.	2,092	88
93	Désencrage Cascades Division Rolland Inc.(Breakyville	232	Transformation of primary and secondary treatment system in 1995.	13	94
94	Désencrage C.M.D. Inc. (Cap-de-la-Madeleine)	352	Introduction of an activated sludge secondary treatment system in 1992.	174	51
95	Papiers Domtar Inc. Centre d'affaires Windsor (Windsor)	31,161	Modification of bleaching sequence in October 1994. Installation of an electrostatic precipitator in the biomass boiler in September 1994. Modernization of biological secondary treatment system in 1995.	10,481	66

	Number and name of industrial plant	1993 Chimiotox Index (C.U.*)	Highlights	1996 Chimiotox Index (C.U.)	Reduction (%)
96	Emballages Stone (Canada) Inc.,. Division Pontiac (Portage-du-Fort)	96,467	Improvement of secondary treatment system in 1992 and 1993. Recovery and treatment of leachate from landfill and chip and bark storage sites. Replacement of a chlorine dioxyde generator to improve efficiency of the process. Addition of gas purifiers to reduce atmospheric emissions (dioxins and furans).	16,218	83
97	BPCO (Division EMCO Ltée.) (Pont-Rouge)	16,716	Separation of domestic sewage and rationalization of use of industrial wastewater in 1994. Introduction of an activated sludge secondary treatment system in 1995.	538	97
98	Papier Masson Ltée. (Masson)	27,206	Wood floatation ended and dry barking unit built in 1994. Introduction of an activated sludge secondary treatment system in 1995.	302	99
99	Industries James MacLaren Inc., Division de la Pâte Kraft (Thurso)	496,843	Modification of primary treatment and introduction of activated sludge secondary treatment system in 1995. *Municipal sewer system hooked up to plant treatment system in 1996 (to be confirmed with project officer).*	7,054	99
100	J. Ford Ltée. (Portneuf)	5,145	Reuse of process water since 1995. Evacuation of domestic sewage to Portneuf municipal sewage system in 1995.	9,541	-85
101	Kruger Inc. Division du papier journal et papier couché (Bromptonville)	50,984	Introduction of a sequential biological reactor secondary treatment system in 1995.	42	99.9
102	Mallette Québec Inc. (St-Léonard de Portneuf)	1,753	Improvements to white water recirculation and pulp recovery operations in 1994.	1,220	30
103	Matériaux Cascades Inc. (Louiseville)	*Not available*	Implementation of effluent reduction measures by means of recirculation of shower water and sealing of pumps in 1993. Start-up of an ultrafiltration unit in 1995 to reuse water more efficiently. Treatment of liquid effluent by Louiseville wastewater treatment station since 1996.	9	*Not available*
104	Papiers Scott Ltée. (Lennoxville)	25,080	Diking of main storage tanks in 1994 to prevent accidental spills.	944	96
105	Les Produits Forestiers E.B. EDDY Ltée. (Hull)	5,368	Since 1993, introduction of water recirculation measures to save water. Introduction of a biofiltration secondary treatment system in 1995.	2,610	51
106	Tembec Inc. (Témiscamingue)	59,317	From 1993 to 1995, separation of process water, improved sludge dewatering system, and more efficient biological treatment system..	72,425	-22
	Total	2,243,627		178, 768	92

* C.U. = Chimiotox units

4.2 Total reduction of SS and BOD_5

Corrective measures introduced at the 38 pulp and paper mills resulted in reduced SS and BOD_5 loads in effluents. The following table shows the reduction in loads from 1993 to 1996.

Table 2

Reduction of SS and BOD_5 from 1993 to 1996 for the 38 pulp and paper mills registered in SLV 2000

Parameter monitored	Load in 1993 (kg/d)	Load in 1996 (kg/d)	Reduction (%)
SS	179,781	87,620	51%
BOD_5	716,620	58,118	92%

4.2.1 Suspended sediments (SS)

The results of analyses of SS in effluents were compiled for all 38 pulp and paper mills. Cleanup measures were introduced by most of the plants in order to reduce loads discharged. From 1993 to 1996, the data obtained reveal a reduction of 92,161 kg/d of SS, or 51% of the initial load.

4.2.2 Biochemical oxygen demand (BOD_5)

The results of analyses of BOD_5 in the effluents of all 38 pulp and paper mills were compiled. From 1993 to 1996, a total reduction in BOD_5 of 658,502 kg/d was observed, representing a cut of 92%. Cleanup measures introduced to meet the new standards that came into effect in the last quarter of 1995 contributed a great deal to the reduction.

4.3 Reduction of persistent bioaccumulative toxic substances

One of the main objectives of the Protection Component of SLV 2000 is the virtual long-term elimination of the discharge of persistent bioaccumulative toxic substances. The persistence of a contaminant is linked to a given environment. It is generally defined in terms of half life in a given environment, in other words, as the length of time necessary for half of the quantity of a substance to disappear through chemical, biochemical and photochemical breakdown processes. The term bioaccumulative refers to the accumulation of chemical substances in living beings directly from the environment or indirectly through food.

A list of eleven persistent bioaccumulative toxic substances prepared by the International Joint Commission (IJC) is being used for the Protection Component. These eleven substances are PCBs, DDT, dieldrin, toxaphene, dioxins, furans, Mirex, mercury, lead alkyl, benzo(a)pyrene and hexachlorobenzene.

The *Assessment of the Virtual Elimination of Persistent Bioaccumulative Toxic Substances*[ref(3)] reports on the reduction of persistent bioaccumulative toxic substances in the 106 industrial plants under SLV 2000 between 1993 and 1996. Among the 38 pulp and paper mills, four of the 11 substances were detected: PCBs, dioxins, furans and mercury.

PCBs were found in the effluent of four pulp and paper mills that recycle paper. PCBs were once used in printing inks and are still used today in countries where PCBs have not yet been banned. The presence of PCBs is sporadic and varies a great deal depending on the supply of paper for recycling. In 1993, the four pulp and paper mills were discharging 28 g/d of PCBs. In 1996, however, according to the data reported by the pulp and paper mills under provincial and federal regulations, none of the 38 pulp and paper mills were discharging PCBs.

SLV 2000 characterizations found mercury in the effluent of one pulp and paper mill. In 1993, this mill was discharging 14 µg/d of mercury. Federal and provincial regulations on pulp and paper mills do not oblige them to measure mercury.

SLAP and SLV 2000 characterizations pointed to dioxins and furans in the effluents of nine pulp and paper mills, chiefly those using chlorine bleaching processes. In 1993, these nine plants discharged

6322 µg/d of dioxins and furans expressed in toxic equivalents to 2,3,7,8-TCDD. Between 1993 and 1996, dioxins and furans discharges were reduced 90% to 628 µg/d.

5. EVALUATION OF TOXICOLOGY

5.1 Effluent toxicity: trout assay

Each month, according to the federal and provincial regulations, pulp and paper mills must conduct an assay to determine the level of acute lethality of their final effluent to rainbow trout. According to Environment Canada reference methods, an effluent is considered toxic if it kills more than 50% of the trout. Ten 10 rainbow trout are exposed to undiluted effluent for 96 hours. The results are expressed in toxic units. The effluent is said to be toxic if the result is higher than one toxic unit.

In 1996, 35 of the 38 pulp and paper plants conducted a monthly test of acute lethality to rainbow trout. The three other plants were not compelled to do so because their effluent went to municipal sewage treatment. Of 420 records gathered, 58 reported exceeding 1 toxic unit, and we can conclude that effluent was non-toxic in 86% of cases.

6. ENVIRONMENTAL IMPACT

6.1 Environmental Effects Monitoring studies

Since the new *Pulp and Paper Effluent Regulations* came into force in 1992, pulp and paper mills have had to carry out Environmental Effects Monitoring (EEM) studies every three years. The first three-year cycle ended in 1996. Fifty-one Quebec mills conducted EEM studies, producing 47 reports, including three joint reports. A summary of the results is being prepared[ref (5)]: *Études de suivi des effets sur l'environnement (ESEE) des fabriques de pâtes et papiers : synthèse des résultats des 47 études réalisées au Québec dans le cadre du cycle 1*. Each EEM study includes several components such as adult fish and invertebrate community surveys and effluent toxicology tests.

The adult fish surveys should facilitate a preliminary assessment of the differences between fish in reference and exposure areas. The results obtained show significant differences between exposure and reference areas in terms of growth (weight and length), reproductive potential (gonad weight and fecundity), age of species and liver weight. However, the extents and types of differences observed are sometimes not constant from plant to plant, species to species or between sexes, pointing to

confounding factors or different reactions among species. Several problems have been pinpointed and recommendations have been made for future monitoring cycles.

Benthic invertebrate surveys consisted in the comparison of the benthic community of an aquatic habitat zone exposed to effluent with that of a comparable unexposed reference zone. It is possible to compare two such zones in 36 locations using the results contained in the 47 reports; in the other cases, physical habitat characteristics are too different. Of the 36 comparisons, nine indicate no difference between the two zones. For the 27 others, the differences noted are mainly in species diversity, abundance and presence of pollution-tolerant or pollution-sensitive species. In the majority of cases (19), it is not possible to state that the differences observed are directly related to plant effluent. Confounding factors such as historical effects or pollution from neighbouring plants may play a role.

Finally, toxicological testing comprised a series of bioassays that measure the sublethal toxicity (effects on growth and reproduction) of final effluent. The bioassays were conducted on one species plant of invertebrate, and fish. They were conducted four times a year for one year. In several mills, bioassays were conducted before and after secondary treatment was introduced, making it possible to evaluate the toxicity of effluent over time as a function of the level of effluent treatment. The results show that secondary treatment seems to significantly improve the quality of effluent with respect to sublethal toxicity.

The results from the first-cycle monitoring exercise are an important and valuable source of data for studying the impact of SLV 2000 pulp and paper plants on the receiving environment. Although incomplete for the time being, the data for the first cycle does indicate trends, and will be used for comparison or reference in future studies.

7. CONCLUSION

The compilation and comparison of data on the effluent from 38 pulp and paper plants in 1993 and 1996 indicates that:

1. Through new federal and provincial regulations and the efforts of the 38 pulp and paper mills, releases of contaminants in effluents have declined. By 1996, toxic liquid discharges from all of the SLV 2000 pulp and paper mills had declined 92% from 1993.
2. Between 1993 and 1996, the SS load of effluents from the 38 pulp and paper plants fell 51%, while BOD_5 was cut by 92%.
3. From 1993 to 1996, persistent bioaccumulative toxic substances present in final effluents were reduced as follows: PCBs were cut by 100% in four pulp and paper mills, Hg was cut by 100% in one mill, and dioxins and furans were cut by 90% in 9 of the 38 mills.
4. In 1996, according to the acute trout lethality bioassay, effluent was non-toxic in 362 of 420 results, or 86% of cases.
5. Environmental Effects Monitoring (EEM) studies conducted in 1996 (first cycle) made it possible to gather a multitude of data that will be used to interpret effects on the receiving environment in subsequent three-year studies.

8. REFERENCES

ref (1) Set of 106 fact sheets "Industrial Plants: Highlights", 1996.

ref (2) *Évaluation externe du modèle CHIMIOTOX*, by Benoît Pigeon, BPC Environnement, for St. Lawrence Action Team, May 1992.

ref (3) *Assessment of the Elimination of Persistent Bioaccumulative Toxic Substances, St. Lawrence Vision 2000, 1993 to 1998,* Protection Component of St. Lawrence Vision 2000, June 1999. Internet: www.slv2000.qc.ec.gc.ca

ref (4) *The Chimiotox Index: : A Toxic Waste Indicator,* St. Lawrence Action Team, St. Lawrence Action Plan, September 1992.

ref (5) *Études de suivi des effets sur l'environnement (ESEE) des fabriques de pâtes et papiers : synthèse des résultats des 47 études réalisées au Québec dans le cadre du cycle 1,* by Claude Langlois and Nathalie Dubuc, Environmental Protection Directorate, Environment Canada, Quebec Region, Montreal, March 1999.

APPENDIX

Chimiotox Index

THE CHIMIOTOX INDEX

a toxic waste indicator

THE CHIMIOTOX MODEL ALLOWS TO EVALUATE THE TOXIC WASTE INDEX IN LIQUID INDUSTRIAL EFFLUENT.

Integration and comparaison of toxic rejects
Indicator of efficiency or contamination
Tool of communication and vulgarization

The Chimiotox model is a mathematical tool for evaluating the overall picture of the toxic substances discharged into the environment. This evaluation is based on the characterization results of toxic substances, following the weighting of the relative toxic potential of each substance present in the waste discharged.

For practical purposes, partial indicators are calculated on the basis of individual results of each toxic substance with a view to integrate these to obtain an overall indicator.

These indicators allow the comparison and integration of important quantities of characterization data.

SALIENT POINTS

Theoretical Principles

- Based on the characterization results of industrial effluents;
- Establishment of a toxic weighting factor (Ftox) specific to each toxic substance and water quality criteria;
- Weighting of the polluting loads with the help of the Ftox;
- Combination of the weighted loads to define an overall Chimiotox index.

Applications

- Simplified assessment of the toxic waste discharged with relative toxicity as a common denominator;
- Integration of the results of several toxic substances in a Chimiotox Unit;
- Integration on several levels: by family of pollutant, industry, group of industries, industrial sector, geographic sector, etc.

THE PROBLEM

A characterization statement contains a wealth of information. On the one hand, it provides results based on conventional parameters (DBO5, MES, etc.) which are encompassing measures and indicators of water quality. On the other, it provides a list of the toxic substances detected in the effluent as well as their concentration.

However, there exists no tool to integrate the results regarding toxic substances, be it to obtain an overall picture of the extent of the discharges caused by toxic substances, or to measure the reduction of the whole of the toxic substances before and following the performance of a treatment system.

In fact, it is not always easy to compare in a qualitative manner the discharge of PCBs, for example, with that of several heavy metals.

The Chimiotox index was designed not only to compare the toxic substances discharged by reducing, with the help of relative toxicity weighting factors, the polluting loads to a common basis of comparison, but also to integrate resultats in such a way as to obtain an overall indication of the waste.

THEORETICAL PRINCIPLES

The Chimiotox Index

The Chimiotox model uses characterization results to calculate the index. These are first expressed as the daily load (kg/d) in the final effluent, to be individually weighted using the toxic weighting factor specific to each pollutant. A partial indicator is then calculated for each substance. Lastly, the overall Chimiotox index is obtained by combining the partial indicators.

$$IC = \Sigma\ (Load_i\ X\ F_{tox\ i})$$

The toxic weighting factor

The toxic weighting factor (Ftox) represents the "weight" to be given to each substance to make possible the comparison of the discharges. Consequently, this factor must be defined with the greatest precision possible.

To do so, an inventory of all toxicological information available on pollutants must be carried out. However, this long and exacting work is already available. It can be found in the "CRITÈRES DE QUALITÉ DE L'EAU" (MEF, 1992).

Water quality criteria represent an exhaustive census of toxicological information on pollutants. This census aims to define the acceptable concentration limit for the protection of human life and aquatic ecosystems. The more toxic the substance, the smaller the criterion.

In the Chimiotox model, two water quality criteria of the Ministère de l'Environnement et de la Faune du Québec were retained, that is the chronic toxicity criteria (CTAC) and those pertaining to the contamination of aquatic organisms (CCOA).

With these two types of criteria, the toxic effects of chronic exposure to a substance and its bioconcentration capacity in the food chain are both taken into account.

The toxic weighting factor is defined as the inverse of the most stringent water quality criterion for each substance (MSCi):

$$F_{tox\ i} = 1/MSC_i$$

$MSC_i = min(CTAC_i, CCOA_i)$

This is a dimensionless number, and represents the toxic potential to be assigned to a given pollutant to evaluate its relative importance in the discharges.

The toxic substances selected

At the moment, approximately 150 priority toxic substances (for which a list of toxic weighting factors has been established) have been selected.

These 150 priority parameters have been divided into 13 families of pollutants stemming from two main categories:

Inorganic Parameters

- Heavy metals
- Other metals
- Anions and others

Organic Parameters

- Fatty acids
- Resin acids
- PCBs
- Non-halogenated VOCs
- Halogenated VOCs
- Dioxins and furans
- PAHs
- Oil and grease
- Phenols
- Phtalates

APPLICATIONS

An example:

The St. Lawrence Action Plan

The St. Lawrence Action Plan (SLAP) is a vast five-year federal/provincial program aimed at cleaning-up, restoring and conserving the St. Lawrence River. One of its major objectives is to reduce by 90% the liquid toxic discharges from 50 industrial plants along the St. Lawrence by 1993.

The Chimiotox model was used in this context to measure the 90% objective.

Using a complete characterization statement for each industry, clean-up predictions were established in such a way as to simulate the discharges measured in 1988, that is year "0" of the SLAP, and to predict the discharges up to 1995.

With this data, the Chimiotox indicators were calculated for each of the plants, and for each year covered by the SLAP.

From then on, it became possible, with the thousands of results on toxic substances discharged into the river by the 50 industrial plants, to calculate an overall index and to follow the evolution of the discharges with a view to assessing the clean-up efforts and mesuring the the extent to which the objective has been achieved.

POTENTIAL AND LIMITS

Potential

The Chimiotox index provides the possibility of comparing and integrating the caracterization results of non-conventional parameters. Several levels of integration may be envisaged to this end: by family of pollutant, industrial sector, geographic sector, etc.

It may be used not only as a waste indicator, but also as an indicator of the performance of a treatment system, for example, or as an indicator of the contamination of a river network or lake.

In addition, the Chimiotox model is a scientific communication and popularization tool that can simplify understanding of the problem of toxic substances.

Limits

Since in the calculation, synergetic effects, bio-availability or toxic substance dilution in the receiving environment, for example, are not taken into account, the Chimiotox model provides only an indication of toxic discharges. Consequently, the Chimiotox index must not be viewed as a measure of the true toxicity of the discharges.

Lastly, the validity of the Chimiotox index depends on the quality of the chemical analysis carried out in the laboratory and on the constant updating of water quality criteria.

INFORMATION

To obtain additional information on the Chimiotox model or on the results of the clean-up efforts of the St. Lawrence Action Plan, contact:

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